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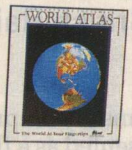

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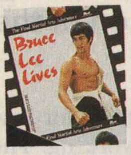

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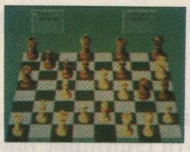

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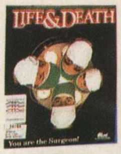

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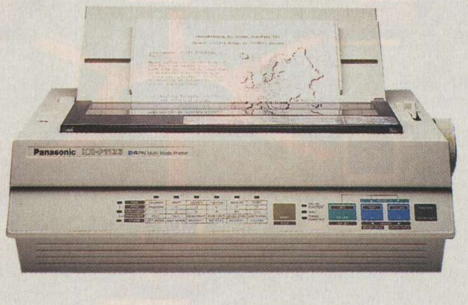

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FEATURE PCW

Along the right lines

The acceptance of the Local Area Network has demystified and popularised the near Black Art of networking. Eric Doyle describes how networks work, with a nod in the direction of that other near Black Art, British Rail.

British Rail should take the credit for inventing the principles of computer networking. There are many similarities in the way that BR transports mail and goods along metal rails from station to station and the way in which computer networks transport mail and data along cables from workstation to workstation. One of the main differences is that users of the railway system have a better understanding of their particular system.

In schematic diagrams of computer systems the network is often represented as a fluffy cloud with lines linking it to the various workstations and peripherals. The implication that what goes on inside the cloud is a complete mystery just about sums up what most network users know. In some ways this is a good thing because a network should be transparent to the user, but to get the best out of the system, or to actually implement one, a

Topology

The electronic or logical shape of a network is known as its topology. Computers are normally linked in one of three arrangements: star, ring or bus.

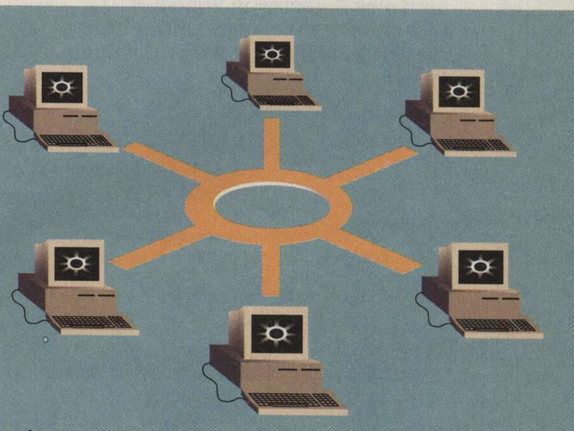
The star topology is the oldest conformation and is based on the original terminal linkage to mainframes and minicomputers. In its raw form, the central unit is a server and each arm of the star is a cable leading from the server to a workstation. The obvious limitation would be the number of connections supported by the server. To alleviate this the centre of the star has been replaced by an intelligent connection device which routes the traffic to the server which is now on its own arm of the star.

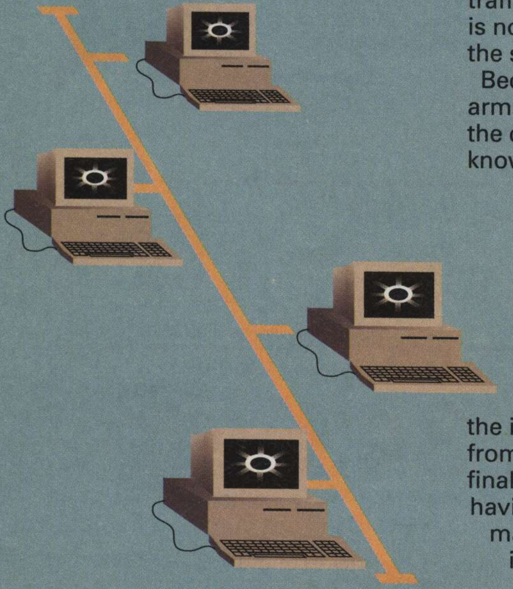
Because in diagrammatic form these arms resemble the spokes of a wheel, the central devices have become known as hubs. Star networks were on the decline but the implementation of a 10Mbit/sec data rate over twisted pair cable has meant that they offer good value for money. As the name suggests, in ring networks the computers are daisy-chained together with the output of the first machine linking directly to the input of the next. This continues from computer to computer with the final machine closing the ring by having its output connected to the first machine. The most common implementation is in IBM's Token Ring system.

A bus network is similar to a ring but instead of the first and last computers in the chain being connected the link is left open.

Nothing is ever as simple as it seems and many networks use combinations of star, ring, and bus. Star networks were going out of fashion until the 10Mbit/sec twisted pair cabling standard appeared. The cable is cheap and easy to surface mount but can only be used for relatively short runs of 100 metres.

By linking a twisted pair star to a repeating hub (a hub which handles links around the star but also amplifies the signal to allow longer effective cable lengths), a hub to hub





knowledge of how it works is essential.

Over the years the technicians of the industry have turned networking into a Black Art masked in jargon and protected within the inner sanctum of the centralised mainframe or minicomputer department. The arrival of cheaper, more powerful PCs has popularised the Local Area Network to the point where it is no longer the preserve of the large corporate company but can be effectively implemented in small offices and branch offices. Just as users in the past have come to accept PC terminology, so the new dictionary of networking terms will become common parlance.

Networks started when two computers were first joined together to swap files. The file transfer was straightforward porting with the data being moved as a constant stream between the two machines. Transferring data in this way duplicates information so the next step was to allow disk sharing. This was the start of peer to peer networking where several machines can access each other's disks. As a peer to peer network grows, backing up and tracking available data becomes a nightmare so the logical response is to place everything on a central disk system, or file server. As processor power has grown, the number of PCs on a network has been increased and consequently the network traffic increase causes the system to grind to a halt.

There are two solutions: one is to localise systems by splitting the system down into smaller interconnecting LANs and then connect those LANs together using bridges.

The other, shorter term, solution is to use the processing power of the file server to pare down the data to what is essential for the user: why send a whole database when just one record is needed. This means the only traffic on the network is essential traffic.

This is what we now call a server but it could be that larger networks actually use several specialist servers for different data types or for controlling and managing the network.

Apart from deciding on the architecture or topology of a network, the way in which information is placed onto the wires has to be decided. The two most prominent systems are Token Ring and carrier sensing multiple access with collision detection, affectionately known as CSMA/CD.

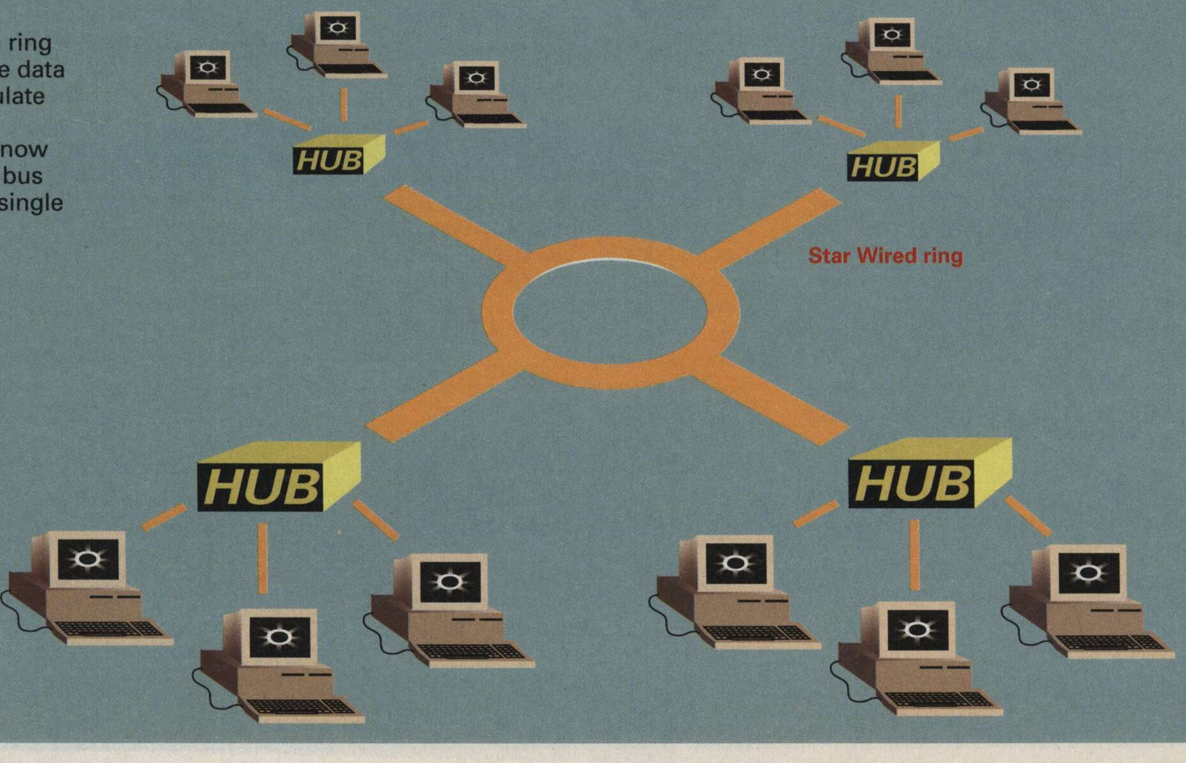
The majority of networks in operation are *baseband* systems: only one packet is carried on the wires at any time. The alternative is to use *broadband* which carries several signals simultaneously by frequency splitting. The receiving station simply tunes into its own allocated frequency in the same way that a radio can be tuned in to a specific radio station. Such systems are expensive but will in time percolate down to more general use as time and technology marches on.

If only one packet is allowed on a network there must be some way to ensure that the rule is not broken. Token Ring and CSMA/CD tackle this in different ways.

CSMA/CD relies on collision detection to ensure that only one node is allowed on the network

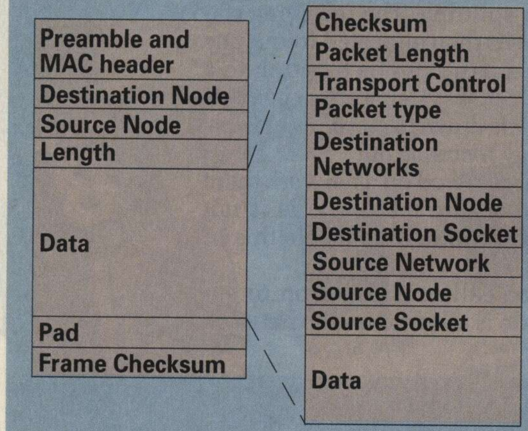
connection using more robust coaxial cable can link two stars and so on to form a ring or bus of daisy-chained hubs each with a subnetwork of starred workstations.

In some ways the ring is preferable to a bus architecture. If a malfunction occurs and a ring is broken, the data can still circulate because the network now resembles a bus topology. A single break on a bus would immediately isolate and bring down part of the system. Effectively it's as though two breaks had occurred on a ring but where the first break is the deliberate choice of not connecting up the ends of the bus to form a ring. A bus has the advantage of not having to be created so that the first and last element of the ring are within suitable proximity to allow the ring to be closed.



Packets

Files are generally as long as a piece of string and to send a complete file on a network as a complete entity would mean tying up resources for a long time. Files therefore have to be broken down into short blocks which are wrapped up, addressed and sent as a stream of little packages, or packets. Monitoring network traffic would show that the first packet travelling from A to B would be followed by a packet from X to Y and maybe a few more packets going between other nodes before the second A to B packet could be sent. In this way everyone gets a fair crack of the whip — unless the egalitarian atmosphere is tilted by prioritising certain types of traffic.



A good example of the chaos that would ensue if packetising was not implemented is apparent when a printer is networked. Printers cannot switch from one printout to another so a buffer is produced to assemble the documents from the network and this is seen as a queue. Printers are slow and on a multi-user system typefaces are shunted in and out of its memory with just about every job that comes in. The result is a bottleneck where during periods of heavy traffic, some users may have their print request rejected for quite some time. If this happened to a client of a database server it could be disastrous with records locked for hours on end.

To break down and reassemble files requires a higher degree of organisation. The system has to be able to tell where a packet is going, which particular block of data it contains and whether it has been corrupted. The process of wrapping data up in its protocol layers and unwrapping it at the other end is known as packetizing and unpacketizing. Personally, I think wrapping and unwrapping would have been quite sufficient or, at a push, packeting and depacketing: Americanisms are always the longer option. The data contained in the packet is the protocol, the specific information which governs how data interchange takes place in a network. The information which is wrapped around the raw data is structured as an enveloping (pronounced envelope-ing not envelop-ing) pattern. Novell's data is wrapped up as the IPX (Internetwork Packet eXchange) packet. It is buried inside a standard Ethernet packet based on the standard Xerox Network System Internet Datagram Protocol (XNS/IDP) as specified by Xerox when it laid the foundations of Ethernet in the late seventies.

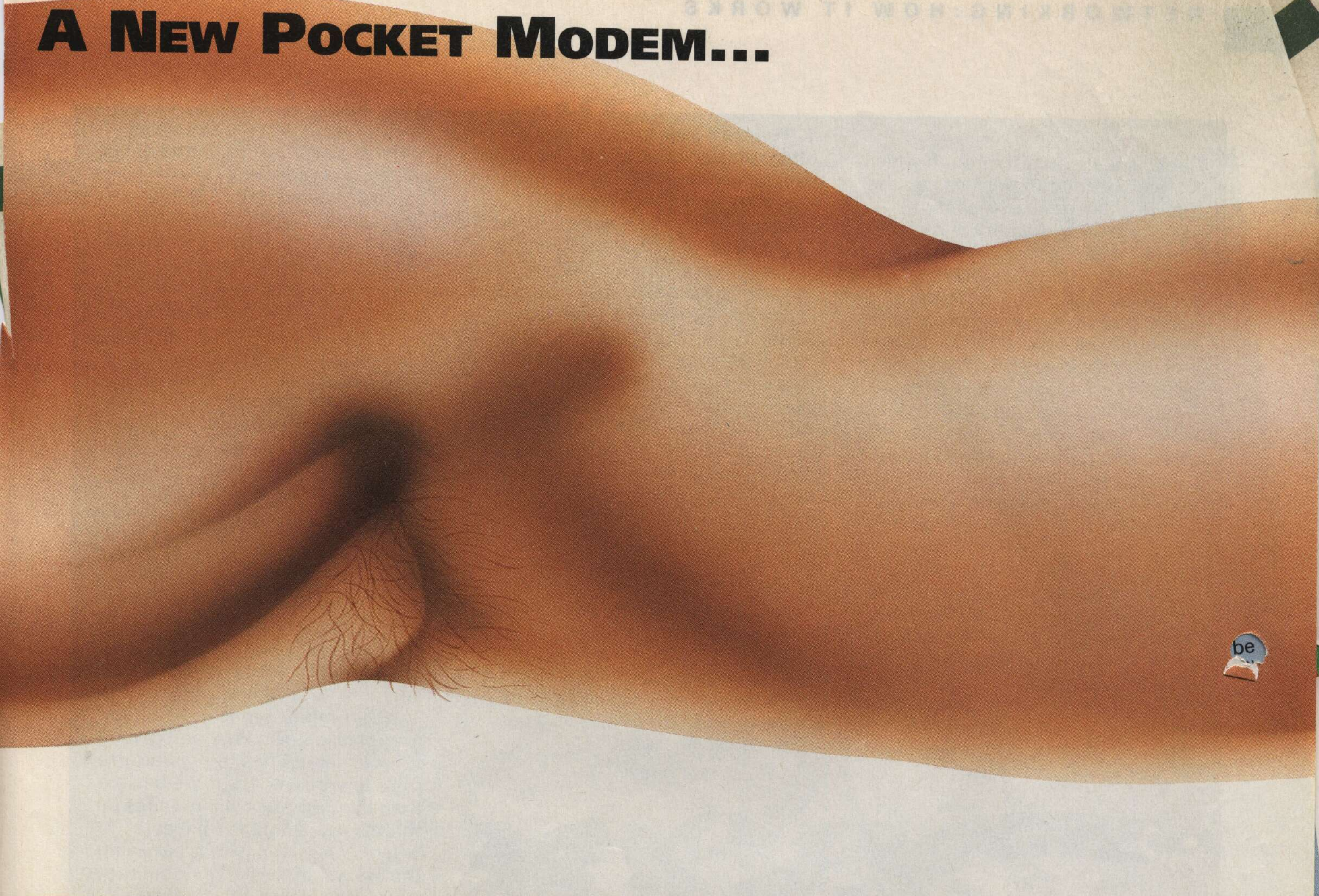
The Ethernet compliant portion of the NetWare packet is headed by the Preamble which alerts the receiving station and other interested elements that this is indeed the start of a package. This is followed by a fixed byte of value 171 which indicates the end of the Preamble and the start of the medium access control (MAC) header. The next information is the destination address so that the receiving station can quickly recognise that the packet is relevant. Next the sender's address (source node) is detailed and the length of the data is specified. This is important because the data space is a finite block of bytes. Most packets will use the full space allotted but the last packet may only be the odd few residual bytes. In this situation the rest of the space is padded with irrelevant bytes and the specified length allows the destination station to strip out the data and ignore the padding. The data in an IPX packet is not just the raw data for transfer but also includes a header of its own to drive the NetWare facilities. The tail of the packet is a Frame Check field, a checksum value to verify that the data was not corrupted in transit.

The IPX portion of the packet is more detailed than the Ethernet section. First a checksum is encountered for later verification that the IPX is uncorrupted. Next the packet length is specified for this portion of the packet and follows similar rules to the length specified in the MAC header. The next few bytes give a more detailed address for the NetWare delivery system. In a NetWare environment each segment of the network is given a unique value so that routing can be more rapidly assessed. This is equivalent to the street where you live and the address of the actual destination parallels the number of the house. There is also an option for a socket number which would be a flat number at a specific address. The source address is similarly spelled out before the data is encountered.

In describing the IPX, the transport control and packet type information was skipped. This is because they have broader implications than just data transfer. Basic Ethernet is not known for its intelligence: it relies on superstructures to provide this. On a NetWare network other tasks are undertaken to increase the intelligence and efficiency of data movement. Like all data on a network, control data has to be packetized in the same way as for transferred raw data. To indicate that this is a different kind of packet the IPX portion carries a single byte figure which defines the type of information carried. This could be routing information protocol (RIP), service advertising protocol (SAP), or NetWare Core Protocol (NCP). The situation is that we have developed packets within packets. These system control packets contain headers within the remaining data space following the IPX packet data which, in turn, has followed the MAC header — a header hierarchy.

RIPs allow the system to find the fastest route between nodes; they update tables within routers and they carry operational information from workstations to routers and back. SAPs indicate which services are available. When a file server, print server or gateway server comes online it releases a SAP to advertise that its services are available. If the specialist server is powered-down again for some reason, a SAP also flags that this has occurred and that the service is no longer available. The NCP packet handles connection control and service request encoding to enable interaction between client and server. When a client establishes a session with a file server it is assigned a connection number which must be quoted in all future service requests during that session so that the server can track which clients are making requests. This offers network control over response priorities and security control.

Although NetWare has been highlighted, all network operating systems use similar packetizing principles. The packet is the software element of the network. If the hardware layers provide the railway track, the packets are the passenger and goods trains which keep the network alive.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Cabling

Cable is the medium through which the network communicates and the type of cable determines the maximum size of a network segment. The standards based naming system, such as 10base2, describes the cable properties: the 10 indicates the number of Mbits transferred each second, Base is short for baseband, and the 2 indicates that this is coaxial cable which can support a network segment that is around 200 metres in length. Sometimes the final figure is replaced by a T or an F to indicate twisted pair or fibre optic cables.

In general, the cables have all been around for many years and still tend to be referred to by their established names rather than their newer standards based nomenclature; so, twisted pair is generally referred to rather than 10baseT or telephone cable. With so many names floating around for the same cable, the picture can seem more complex than it actually is. There are three types of cable currently in use for networks:

1. Twisted pair cable (10baseT) is often referred to as telephone cable but it is generally of higher quality than the CW108 cable that BT uses for telephone systems. To set the record straight, it is actually the equivalent of BT's new CW1700 cable.

Although the basic unit of this cable is two wires twisted around each other, it often appears as bundled multicore cable with several pairs contained in a single sheath. The cable is thin and is susceptible to 'crosstalk' interference caused when the magnetic fields generated by a signal passing through the cable induces a duplicate, though weaker, signal in neighbouring cables. This unwanted effect can cause data loss and the longer the cable, the greater the interference. To combat this, twisted pair comes in two flavours: shielded (STP) and unshielded (UTP). STP differs from UTP in that the individual cable pairs within the multicore cable are sheathed in a metallic braid which acts as a barrier to the crosstalk effect.

The debate about the suitability of UTP on a network is an area of hot debate. For standard Token Ring and especially for the 16Mbit/sec upgrade, IBM champions STP, or Type 1, cable: purely for technical reasons you understand and not because of the company's heavy investment in the manufacture of the stuff. But the UTP camp is gaining converts all the time.

2. Coaxial cable (10base5 or 10base2) is the same sort of cable that is used for domestic TV aerial connections and was the original standard for Ethernet network connection. The cable has a heavily insulated central copper core which is sheathed in braided copper and covered in plastic. Coaxial, or co-ax, is available in two varieties: thick (10base5) and thin (10base2). The thicker cable is also known as thick wire Ethernet and can support segment sizes of up to 500 metres. The thin cable, thin wire Ethernet, is a relative newcomer and gained the nickname Cheapernet because of its lower cost. It is more flexible than thick wire but still requires far more space than the multicore twisted pair. Thin wire is surviving the assault of twisted pair but may eventually disappear because twisted pair is cheaper and its segment limit of 100 metres is not too far behind thin wire's 185 metres.

3. Fibre optic cable (10baseF, fibre or FDDI cable) is the future of larger networks. Instead of electrical impulses the system passes light through special filaments. It's rather like a hi-tech version of semaphore. Transducers at either end of the cable convert digital electrical signals into light impulses and vice versa. Fibre optic networks are known as FDDI (Fibre Distributed Data Interface) systems but they are still very expensive. The cable itself is reasonably competitive but the transducers add to the cost and, until recently, cables had to be spliced off site ready for installation. The ability to join cables on-site has helped FDDI adoption, but it is still not generally acknowledged as a desktop connection medium.

The typical configuration of a network would be to use twisted pair or thin wire for desk to desk connections within an office. Longer cable jumps between floors or buildings would probably be thick wire or fibre optic cables.

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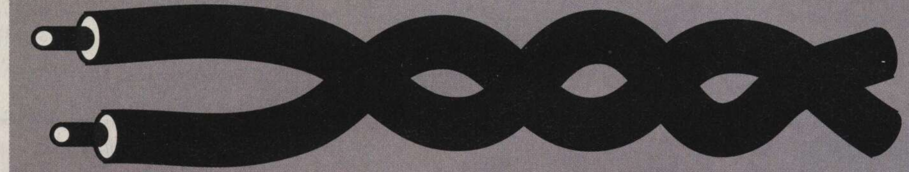
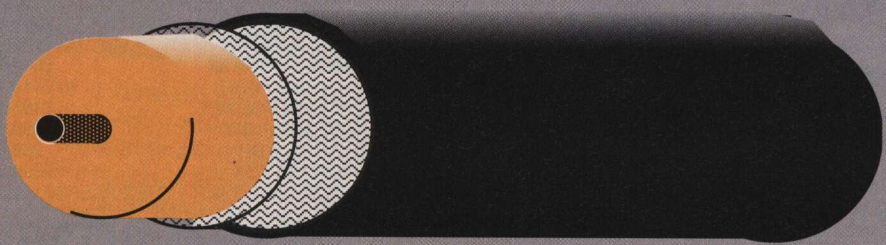


10 Base T Twisted pair
Copper conductors in plastic sheath, twisted to limit externally induced signals



10 Base 2/5 coaxial
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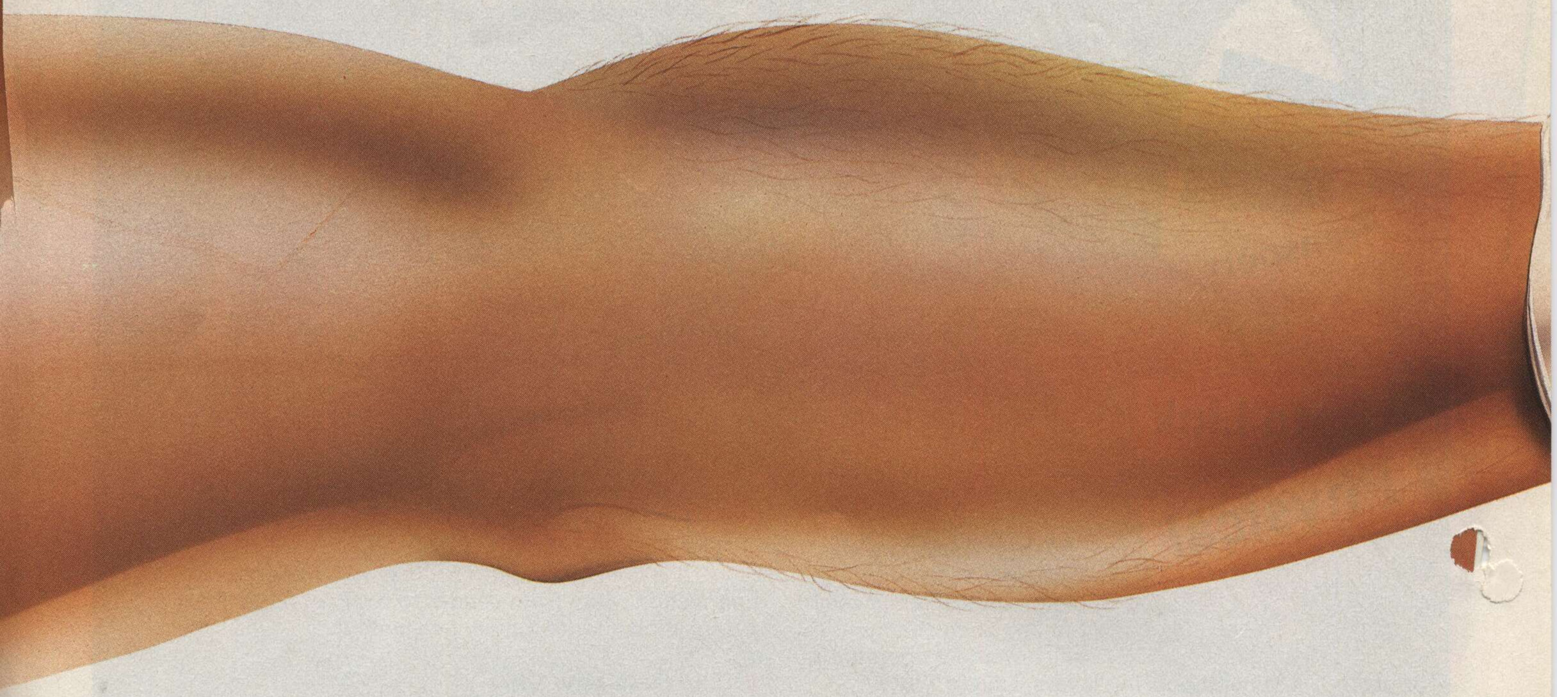

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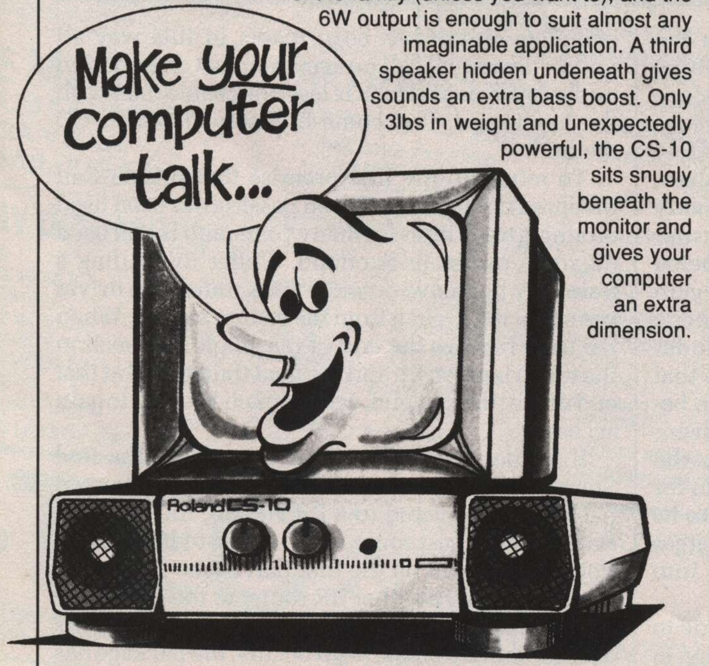

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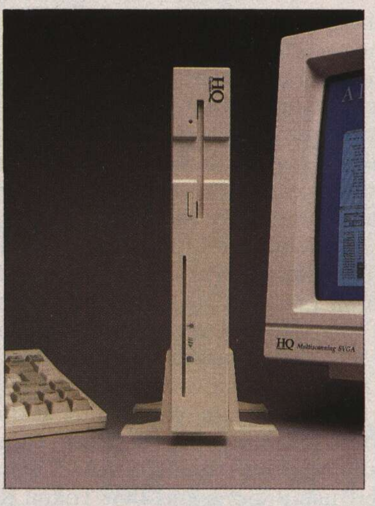

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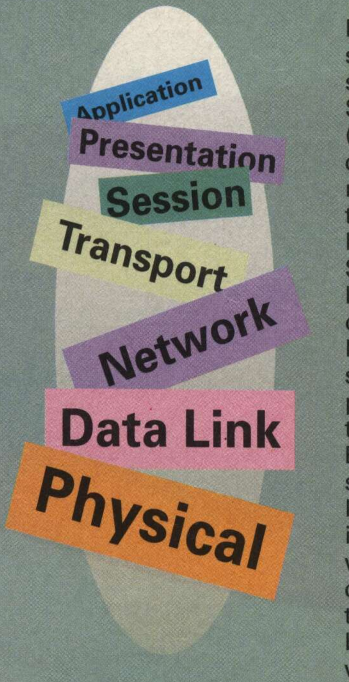
The seven layers of the OSI



The user's desire to base IT investment on standards has led bodies such as the International Standards Organisation (ISO) to look more closely at the structure of networks. This has led to the definition of a seven layer model for Open Standards Interconnection (OSI) to describe the various levels of networking systems from the physical connections up to the user interface. Each layer provides services to the adjacent layers but remains independent. In other words, any layer can be changed in line with technological advances but any such changes will not affect operations or protocols in neighbouring layers. Layers 1 to 3 address the connections used in the system, layers 4 to 6 handle interoperation standards for applications, and the final layer defines specific user applications. Layers 1 and 2 specify the hardware but Layer 2 also has a software component which complements those specified in Layers 3-7.

1. The Application Layer
Layer 7 in the OSI model lies closest to the user. It provides the services such as file transfer, remote file access, database management, and communications between applications. This is where the user software lies alongside support applications such as electronic mail. It is responsible for formulating and shaping the raw data that will be sent on the network.

2. The Presentation Layer
Layer 6 converts raw data to a standard format to negate proprietary data formats and open the way to data interchange between systems from different vendors.

3. The Session Layer
Layer 5 maintains dialogue between any two devices on the network. If the dialogue is broken, this level is where the status is recorded so that communications can pick up where they left off when the link is re-established.

4. The Transport Layer
Layer 4 is the link between the user and the network and forms the baseline level of network operating systems, though these may also offer services which are covered by Layers 5 and 6. It controls the sequential transfer of blocks of data so that received information does not become garbled. It also monitors the data link layer so that system errors can be flagged to the user.

5. The Network Layer
Layer 3 is the pathfinder. This is where the physical connection route from sender to recipient is defined, established and ultimately terminated.

6. The Data Link Layer
Layer 2 synchronises transmission and stipulates error detection and recovery of transmitted information. It ensures the maintenance of a connection made by Layer 3. This is also the level at which packet structure is defined. Example systems would be Token Ring and Ethernet cards.

7. The Physical Layer
Layer 1 relates to the types of plugs, connectors and sockets used in a local or wide area network. It also specifies the ratings and types of signals which are compatible with the various cabling media. Basic elements such as voltage, bit timing and modulation are set at this level.

at a time. A node is a connection point on the network — often a workstation but could equally be other network elements such as routers. It is possible that two nodes may detect that the bus is free at the same time and begin transmitting. Immediately the system senses that a collision is taking place, both nodes stop transmitting. After a randomly generated time delay each node will try to transmit again. The chances of the two delay times being identical is extremely slim so each node will gain control of the network — assuming another node doesn't start up and cause another collision. Under heavy workloads contention for access means that some nodes may slow down to a snail's pace because cable length may put them at the disadvantage of a crucial split second. Generally, the recommendation is that CSMA/CD is suitable for smaller installations and that Token Ring is to be preferred for larger networks. Alternatively, larger CSMA/CD networks can be broken down into bridged subnetworks.

The token of Token Ring is passed from node to node until it is grabbed by a node with something to say. Once the token is in use nothing else can gain access until the packet has been delivered. Then the token is passed to the next node and so on until a complete circuit has been made. In this way all nodes have equal call on access so that degradation under heavy workloads is less noticeable than with the haphazard, first come first served CSMA/CD method.

To return to my first premise that British Rail invented networking. Token passing has been used on single track lines for many years, and is still used on some routes in Scotland. Under this ruling a train may not move onto the track unless the driver has collected a token from the station master. When the train reaches the end of the single line section the token is given up and the next train to call at that end of the line can pick up the token in order to gain access.

If further proof is necessary, consider the Red Star package delivery system. A correctly addressed package is delivered to a BR station, the Red Star staff plan the best route for it to take to its destination and set it off on the first part of the journey. It is picked up by another BR router at the end of the first leg and sent off again until it reaches its destination. If a breakdown occurs, the package has to be re-routed and sometimes fails to appear at the destination at all. Yes, the parallels certainly hold true throughout the analogy. ■